FM

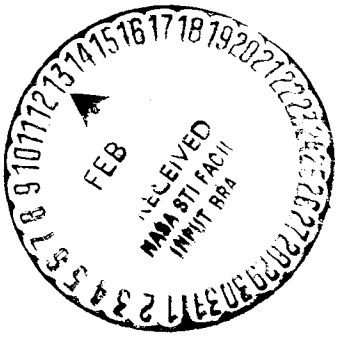
Internal Note No. 69-FM-17

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MSC INTERNAL NOTE NO. 69-FM-117

May 6, 1969

APOLLO 8
RTACF POSTMISSION REPORT



Flight Analysis Branch

MISSION PLANNING AND ANALYSIS DIVISION

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

MSC INTERNAL NOTE NO. 69-FM-117

PROJECT APOLLO

APOLLO 8 RTACF POSTMISSION REPORT

By Larry D. Davis
Flight Analysis Branch

May 6, 1969

MISSION PLANNING AND ANALYSIS DIVISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

Approved: Charlie C. Allen
Charlie C. Allen, Chief
Flight Analysis Branch

Approved:
John P. Mayer, Chief
Mission Planning and Analysis Division

TABLES

APOLLO 8 RTACF POSTMISSION REPORT

By Larry D. Davis

SUMMARY

This document contains a summary of the Real-Time Auxiliary Computing Facility (RTACF) support of the Apollo 8 mission. Included in this document are the following:

1. A description of the computations made by the RTACF during Apollo 8
2. RTACF mission activities
3. A summary of all RTACF computations
4. RTACF manpower utilization
5. A typical RTACF support team
6. The flight control simulation summary

INTRODUCTION

The Real-Time Auxiliary Computing Facility (RTACF) support of the Apollo 8 mission began with support of flight control simulations on October 26, 1968. The RTACF supported 25 flight control simulations between October 26 and December 17, 1968, and provided 24-hour support for the 147-hour Apollo 8 mission. This document summarizes all RTACF Apollo 8 support, both mission and simulations, and includes a detailed tabulation of manpower usage.

DISCUSSION

This document contains a summary of RTACF support of the Apollo 8 simulations and mission. A brief description of the types of RTACF computations made in the support of Apollo 8 is presented in table I. A summary of RTACF activities as a function of ground elapsed time (g.e.t.)

is presented in table II. The number of computations made for each type of capability required during the Apollo 8 mission are listed in table III. A tabulation of Mission Planning and Analysis Division (MPAD) personnel who supported the Apollo 8 mission is provided in table IV. A typical RTACF team required to support simulations and the Apollo 8 mission is listed in table V. A summary of flight control simulations supported by the RTACF is presented in table VI. Finally, RTACF manpower usage for the Apollo 8 mission is summarized in table VII. Total RTACF manpower usage exceeded 12 000 man hours for the Apollo 8 simulation and mission support.

TABLE I.- TYPES OF RTACF COMPUTATIONS

1. Translunar midcourse - The translunar midcourse is the computation of a midcourse maneuver designed to return the spacecraft (SC) to the desired trajectory for either a lunar orbit injection (LOI) maneuver or a free-return flyby. Certain reaction control system (RCS) optimization computations were available only in the RTACF program.

2. Transearth midcourse - The transearth midcourse is the computation of a midcourse maneuver designed to return the SC to the desired entry trajectory.

3. LOI - The LOI is the computation of the lunar orbit insertion maneuver.

4. LOI-2 - The LOI-2 is the computation of the circularization maneuver after LOI-1.

5. Return to earth (RTE) - RTE computations provide time of an abort maneuver, ΔV, burn attitudes, time of entry interface, and time of landing for a specified recovery area. Additional data such as maximum g, velocity and flight-path angle at entry interface (EI) are also available. The RTACF verified all return-to-earth data passed to the Apollo o crew.

6. Apollo generalized optics program (AGOP) - The AGOP is used to compute the following data.

   a. Cislunar navigation (star/landmark and star/horizon sighting information)

   b. Reference body locations

   c. Passive thermal control (PTC) attitude definition

   d. Pitch angle to lunar terminator or horizon (for LOI alinement check); this information was available only from the RTACF

7. Spacecraft system and consumable computations - Spacecraft system and consumable computations involve the computation of predicted RCS usage and the quantity of RCS fuel, oxidizer, and cryogenics that remain. Electrical power usage profiles are also computed.

8. Earth-moon-sun (EMS) look angles - The EMS is the computation of look angles from the SC to the earth, the moon, and the sun. The results were used for communication and thermal analysis during the Apollo 8 mission.

TABLE I.- TYPES OF RTACF COMPUTATIONS - Continued

9. Telescope look angles - Telescope look angle computation provides right ascension and declination of the SC for several observatories. This information was provided for the following sites.

a. Lick Observatory, Santa Cruz, California

b. Museum of National Science, Denver, Colorado

c. Boeing Geo-Astrophysics Laboratory, Seattle, Washington

d. Haleakala Observatory, Wailuku, Maui, Hawaii

e. Jodrell Bank Observatory, London, England

f. Manned Spacecraft Center, Houston, Texas, Building 16

Several pictures of Apollo 8 were obtained through the use of the pointing data.

10. Conversion of vectors for the Jet Propulsion Laboratory (JPL) - Conversion of a state vector to the true of date system was performed. These state vectors were used by the JPL to compute acquisition data for their 240-ft antenna. The antenna was used to receive television pictures during the Apollo 8 mission.

11. Crew chart update - The crew chart update is the computation of attitudes and abort maneuver ΔV required immediately after translunar injection (TLI) or LOI-1 cutoff. The information was passed to the Apollo 8 crew.

12. Maneuver confirmation - Maneuver confirmation refers to the application of nonnominal components of ΔV (residuals) from a particular SC maneuver to the nominal maneuver target to determine the actual SC trajectory.

13. Maneuver evaluation - The maneuver evaluation processor computes a maneuver that is equivalent to a maneuver which has been performed. A preburn vector and a postburn vector are propagated to the impulsive maneuver time. At this point, the equivalent SC attitudes and external ΔV components are computed.

14. Radiation - The radiation computation is a time history of radiation dose and dose rate for a specified time period.

15. Solar Particle Alert Network (SPAN) date reduction - SPAN data reduction is the reduction of data received from the Solar Particle Alert Network. The data are used to determine if solar activity might endanger the safety of the crew.

TABLE I.- TYPES OF RTACF COMPUTATIONS - Continued

16. LOI GO/NO-GO computation - LOI GO/NO-GO computation is an evaluation of the velocity component difference between the command module computer (CMC) and the instrument unit (IU) during TLI. This evaluation is used to determine whether the CMC is GO/NO-GO for LOI.

17. Onboard navigation and Manned Space Flight Network (MSFN) evaluation - The onboard navition and MSFN computations determined the accuracy and validity of the onboard navigation sightings and the MSFN tracking.

18. Mass properties computations - The mass properties computations include the following.

a. c.g./weight tables (used by the Real-Time Computer Complex (RTCC) and the RTACF trajectory processor)

b. Entry aerodynamics tables (used by the RTCC and the RTACF entry processor)

c. SC digital autopilot (DAP) data

19. Groundtracks - Groundtracks are time histories of latitude, longitude, altitude, and revolution number of the SC referenced either to the earth or to the moon.

20. Command and service module (CSM) or S-IVB navigation update - The CSM or S-IVB navigation update formatting of a state vector is in the correct units for uplink to either the CMC or the IU.

21. Delay time (slant range) - The delay time (slant range) is a computation of slant range from a selected site to the SC and delay time for a radio signal to travel from the site to the SC.

22. Entry data for Track Controller - Entry data for the track controller involves the computation of the following data.

a. Service module (SM) pointing data (used to track the SM during entry)

b. Pointing data for the entry ship (used to determine the optimum location for the entry ship)

c. Time and position of the entry fireball (used to photograph the entry fireball)

23. Post Flight Analysis Office (PFAO) computations - PFAO computation of various trajectory parameters which are used by PFAO to prepare data summaries are for NASA headquarters.

TABLE I.- TYPES OF RTACF COMPUTATIONS - Concluded

24. Radar tracking - Radar tracking is a computation of look angles from a ground site to the SC. These data were used primarily by the Public Affairs Officer for release to the general public.

25. Look-angle time history tape - The look-angle time history tape provides attitude time histories as well as ground to SC look-angle time histories to permit evaluation of the SC antennas.

26. Generation of ephemeris tape - The ephemeris tape was used in conjunction with downlinked telemetry (TM) gimbal angles for SC thermal evaluations.

27. General computation - General computations include the following.

a. Checkout monitor

b. Flight Dynamics Officer (FDO) orbit digitals

c. Public Affairs Office Data

d. Space Digitals

e. Check cases

TABLE II.- APOLLO 8 RTACF ACTIVITIES

(a) Pre-lift off activities

Time, C.S.T. December 21, 1968	Event
01:00	RTACF team 3 on duty
01:15	Advised NORAD of countdown status
01:30	Received preliminary CSM weight and c.g. data
02:02	Computed reference CM and CSM c.g. locations
02:16	Computed t minus 3:30 beginning of mission (BOM) c.g. and DAP
02:27	Computed t minus 3:30 BOM aerodynamics based on predicted liftoff potable and waste water
02:30	Computed t minus 3:30 BOM c.g.'s and DAP with updated weights
02:31	Advised NORAD of countdown status
02:50	Computed t minus 3:30 BOM aerodynamics with updated c.g. locations
03:02	Computed aerodynamics checks to determine sensitivity of L/D to c.g. change
03:15	Update RTACF processors with T minus 3:30 c.g.'s aerodynamics. The RTCC was also updated with t minus 3:30 data at this time.
03:40	Recomputed the premission block data (Block 1) with the t minus 3:30 c.g. and aerodynamic data.
03:55	Advised NORAD of countdown status.
04:00	Computed 2-1 CLA with the t minus 3:30 c.g. and aerodynamic data.
04:15	Processed three sets of SPAN radiation data
04:20	Computed EPO ground tracks through a GET of 10 hours based on predicted insertion vector and assuming no TLI burn.
04:55	Advised NORAD of countdown status.
05:15	Received data to update the PVT Program based consumables loaded on the spacecraft.
05:24	Computed true of date vector conversion for Goldstone and NORAD based on predicted TLI cutoff vector.
05:30	Computed PVT data
06:00	Advised NORAD of countdown status
05:50	Received t minus 1 hour predicted lift-off weight data
06:14	Computed midcourse maneuver (MCC) based on predicted TLI cutoff vector
06:51	Lift-off

TABLE II.- APOLLO 8 RTACF ACTIVITIES - Continued

(b) Mission activities

Time, hr:min, g.e.t.	Event
00:01	Received lift-off and guidance reference release (GRR) time for SC and IU
00:12	Computed insertion PFAO data
00:13	Computed nodal targets
00:13	Computed lift-off REFSMMAT
00:19	Computed earth orbital groundtracks through revolution (REV) 6, assuming no TLI maneuver
00:21	Computed S-IVB navigation (NAV) update
00:23	Computed retrofire quantities for area 1-4
00:25	Computed true of date vector for NORAD; data was voiced to NORAD
00:34	Computed retrofire quantities for area 2-1
00:41	Computed true of date vector for Goldstone based on predicted TLI cutoff vector
00:42	Computed midcourse correction 1 (MCC-1) based on predicted TLI cutoff vector
00:43	Computed TLI plus 10 minute crew chart update information
01:05	Computed three sets of AGOP data and PTC data
01:10	Computed IU NAV update
01:23	Computed TLI plus 90 minutes and TLI plus 4 hour RTE with predicted TLI cutoff vector
01:45	Computed MCC-1 based on predicted TLI cutoff vector
02:05	Computed CSM NAV update
02:50	TLI maneuver was performed
03:05	Computed STAR OF HOPE data (two computations)
03:13	Computed range and delay time for Goldstone (i.e., range from SC to Goldstone)
03:19	Compute RTE with maneuver at g.e.t. = $11^h00^m00^s$
03 20	First separation maneuver performed
03:28	Computed MCC-1
03:35	Computed PFAO data for TLI ignition and cutoff
03:44	Computed sun aspect angles
03:53	Computed PFAO data for first separation maneuver
04:45	Second separation maneuver performed
04:55	Computed four sets of AGOP data

TABLE II.- APOLLO 8 RTACF ACTIVITIES - Continued

(b) Mission activities - Continued

Time, hr:min, g.e.t.	Event
05:04	Converted vector for NORAD and Goldstone
05:06	Computed MCC-1
05:16	Computed RTE Data (TLI plus 4 hour abort)
05:33	Computed radiation dosage from g.e.t. = $3^h00^m00^s$ through g.e.t. = $4^h10^m00^s$
06:02	Computed range and delayed time for Madrid
06:04	Computed PFAO data for second separation maneuver
06:09	Computed MCC-1
06:10	Generated RCS optimum solution for MCC-1
06:14	Computed RCS scan for MCC-1
06:20	S-IVB vector received from Goddard
06:32	Converted S-IVB vector and passed it to NORAD
06:38	Recomputed SPAN run made during prelaunch
06:40	Computed CSM/S-IVB relative motion
06:42	Computed radar tracking data for MSC
06:44	Computed MCC-1
07:13	Computed DAP
07:27	Updated weights passed to ACR
07:40	Generated radar time history tape (antenna data)
07:45	Generated ephemeris tape (thermal/antenna required)
07:50	Computed four sets of telescope pointing data for the following 1. Lick 2. Denver 3. Seattle, Hawaii, France 4. Building 16 (MSC)
07:51	Computed four sets of AGOP data
07:52	Computed EMS look angles
08:30	MSFN tape, required by evaluation team, requested by trajectory support chief
08:51	Computed PTC data (three cases)
09:00	Processed TLI CMC and IU ΔV data to support LOI GO/NO-GO computations
09:12	Computed h_{pc} conditions for S-IVB

TABLE II.- APOLLO 8 RTACF ACTIVITIES - Continued

(b) Mission activities - Continued

Time, hr:min, g.e.t.	Event
09:15	Computed MCC-1
11:40	First low-speed MSFN tape was provided to evaluation team
10:30	Generated RCS scan for MCC-1
11:40	Maneuver evaluation for MCC-1 computed
11:42	Computed two RTE solutions
12:00	Updated weights passed to ACR
12:02	Computed RTE solution (abort scan)
12:20	Computed MCC-2
12:25	Generated RCS scan for MCC-2
12:33	MSFN tape passed evaluation team
12:50	Computed checkout monitor to be used with STAR OF HOPE data
13:55	Computed STAR OF HOPE data
13:56	Converted and passed vector to NORAD and Goldstone
14:06	Generated radar time history tape (antenna data)
14:10	Updated weights passed to ACR
14:59	Computed radar tracking data for building 16 (MSC) two computations
15:00	Computed relative motion data for CSM/S-IVB
15:10	Computed LOI GO/NO-GO data based on processed TEI data
15:15	Computed MCC-4
15:16	Computed MCC-3
15:30	Computed RTE data (abort scan)
15:40	Computed two sets of AGOP data
15:51	Computed range and delay time for Canberra (Honeysuckle Creek, HSK)
17:29	Generated maneuver evaluation data for MCC-1
17:30	Computed PFAO data for MCC-1 (two computations)
17:41	Computed CSM/S-IVB relative motion
17:50	Computed RTE date (abort scan)
17:52	Computed RCS scan for MCC-1
17:55	Computed three sets of AGOP data
18:00	Computed PTC data
18:31	Onboard NAV data for evaluation team passed to ACR
18:42	Converted vector for NORAD and Goldstone
18:45	Computed RTE data (pre-h_{pc} abort)

TABLE II.- APOLLO 8 RTACF ACTIVITIES - Continued

(b) Mission activities - Continued

Time, hr:min, g.e.t.	Event
18:53	Computed RTE data (pre-h_{pc} abort)
18:55	Computed maneuver evaluation data for MCC-1
19:31	Computed EMS look angles
19:38	Generated ephemeris tape (thermal and antenna required)
19:39	Computed range and delay time for HSK
19:47	Computed RTE data (abort scan)
19:55	Computed RTE data (return to earth digitals)
20:20	Converted vector for evaluation team
20:28	Computed range and delay time for Madrid
20:30	Computed RTE data (abort scan)
20:58	Computed pointing data for all telescope sites
21:05	Computed nodal targets
21:30	Computed EMS look angles
21:51	Computed RTE data (abort scan)
22:10	Low-speed MSFN passed to ACR for evaluation team use
22:30	Evaluation team computation
22:55	Difference in RTCC/RTACF solutions of pre-h_{pc} abort; both solutions valid
22:59	Converted vector for evaluation team
23:18	Computed PTC data
23:23	Computed AGOP data
23:26	Computed EMS look angles
23:57	Computed RTE data (verification of block data); two computations
24:05	Computed DAP data
24:18	Computed predicted RCS usage data
24:49	Generated radar look angle time history tape (antenna required)
24:50	Computed radar tracking data for MSC
24:55	Converted and passed vector to NORAD and Goldstone
24:58	Computed RTE (return to earth digitals)
25:25	Generated midcourse scan data for MCC-4
25:30	Computed AGOP data
25:59	Computed CSM/S-IVB relative motion data
26:05	Computed checkout monitor at g.e.t. = $66^{h}00^{m}00^{s}$

TABLE II.- APOLLO 8 RTACF ACTIVITIES - Continued

(b) Mission activities - Continued

Time, hr:min, g.e.t.	Event
26:18	Computed MCC-1 PFAO data
26:41	Computed EMS look angles
27:25	Generated midcourse scan data for MCC-4
27:50	Computed RTE data (abort scan and RTE digitals)
28:30	Computed two sets of AGOP data
28:36	Computed flyby maneuver
28:45	Computed RTE data (two RTE digitals)
29:20	Converted and passed vector to NORAD and Goldstone
30:08	Computed PTC data
30:39	Converted octal data for evaluation team
30:40	Computed four sets of AGOP data
31:00	Computed EMS look angles
31:35	Computed range and delay time for Goldstone
31:52	Computed PFAO data for two separation maneuvers
32:00	Converted onboard NAV data for evaluation team
32:10	Generated ephemeris tape (thermal and antenna required)
32:56	Computed local horizon attitudes at $3^h45^m00^s$
34:25	Computed RTE data (RTE digitals)
34:36	Computed local horizon attitudes at $4^h15^m00^s$ g.e.t.
34:58	Computed RTE data (RTE digitals)
35:05	Computed RTE data (RTE digitals)
35:06	Computed space digitals for S-IVB
35:10	Computed CSM/S-IVB relative motion
35:12	Converted and passed vector to NORAD and Goldstone
35:20	Generated RCS scan for MCC-2
35:40	Computed SPAN data
35:42	Reformatted look angle time history tape
36:43	Computed range and delay time for Goldstone
37:24	Converted onboard NAV data from octal for evaluation team
37:45	Computed RTE data (abort scan)
38:13	Computed MCC-3
37:30	Trajectory support chief informed that no additional empheris tapes were required

TABLE II.- APOLLO 8 RTACF ACTIVITIES - Continued

(b) Mission activities - Continued

Time, hr:min, g.e.t.	Event
38:15	Computed MCC-4
39:01	Computed RTE data (abort scan)
39:13	Reformatted look angle time history tape
39:25	Discovered that Goddard S-IVB vectors were not in correct system; all previous S-IVB runs were incorrect because of bad vector (incorrect coordinate system)
39:26	Computed MES look angles
39:32	Computed S-IVB space digitals
39:34	Computed CSM/S-IVB relative motion
39:37	Computed MCC-4
39:38	Computed two sets of AGOP data
40:20	UNIVAC 1108 processor 1 down until 41^h58^m g.e.t.
40:30	RTCC used RTACF solution (in SC setting) and verified that both pre-h_{pc} solutions were correct
40:40	Low-speed MSFN tape passed to evaluation team
40:47	Converted vector for evaluation team
41:00	UNIVAC 1108 processor 0 down until $41^h30^m00^s$ g.e.t.
41:30	Computed CSM/S-IVB relative motion
42:00	Passed undated weights to ACR
42:15	Computed flyby maneuver $47^h00^m00^s$ g.e.t.
42:20	Computed flyby maneuver $62^h00^m00^s$ g.e.t.
42:44	Converted vector for evaluation team
43:10	Computed detailed maneuver table (DMT) for MCC-4
43:23	Computed RTE data (abort scan)
43:25	Generated look angle time history tape
43:35	Computed pointing data for telescope sites
43:48	Computed RTE data (block data verification)
43:53	Generated look angle time history tape
43:59	Converted and passed vector to NORAD and Goldstone
45:00	Computed lunar groundtrack data
46:15	Additional data for evaluation team passed to ACR
46:39	Computed CSM NAV update

TABLE II.- APOLLO 8 RTACF ACTIVITIES - Continued

(b) Mission activities - Continued

Time, hr:min, g.e.t.	Event
47:13	Computed AGOP data
47:20	IBM 7094 computer down for 3 hours for maintenance
47:35	Computed DAP data
47:38	Computed aerodynamics
47:56	Computed AGOP data
48:00	Computed five sets of AGOP data
48:10	Computed PTC data
48:17	Passed low-speed MSFN tape to evaluation team
48:19	Computed EMS look angles
48:23	Converted and passed vector to NORAD and Goldstone
49:06	Computed two sets of AGOP data
49:30	Computed PTC data
49:40	Computed EMS look angles
49:42	Computed PTC data
50:45	Computed EMS look angles
50:46	Computed RTE data (abort scan)
51:00	Computed PTC data
51:10	Computed nodal targets
51:12	Computed one point of LOI crew chart data
51:40	Computed AGOP data (six cases)
51:42	Computed range and delay time for Madrid and Ascension
51:45	Computed RTE solution (abort scan)
52:00	Computed entry aerodynamics
52:10	Computed LOI crew chart data
52:20	Converted and passed vector to Goldstone and NORAD
53:01	Computed range and delay time for Madrid
53:05	Computed EMS look angles
53:10	Computed MCC-4
53:25	Recomputed LOI crew chart data
53:30	Computed PTC data
54:40	Generated look angle time history tape
56:00	RTACF updated all programs with the lift-off plus 53 hour entry aerodynamics
56:10	Computed X-Y-Z nodal target
56:20	Generated RCS scan for MCC-4

TABLE II.- APOLLO 8 RTACF ACTIVITIES - Continued

(b) Mission activities - Continued

Time, hr:min g.e.t.	Event
57:10	Computed EMS look angles
58:00	Recomputed LOI crew chart data (two runs)
58:15	Computed optimized MCC's after flyby
58:20	Computed nodal targets
58:30	Computed lunar groundtracks assuming nominal LOI-1 and LOI-2
58:40	Confirmed gimbal angles for LOI crew chart data
58:42	Generated additional data for LOI crew chart update
58:45	Generated look angle time history tape
59:00	Computed nodal targets
59:13	Computed RTE solution (return to earth digitals)
59:30	Computed RTE solution (return to earth digitals)
59:48	Computed entry aerodynamics (two cases)
60:20	Computed EMS look angles
60:30	Computed entry aerodynamics
60:45	Computed MCC-4
61:09	Computed EMS look angles
61:30	Performed maneuver evaluation for MCC-4
61:38	Computed LOI-1 and LOI-2
61:42	Converted and passed vector to Goldstone and NORAD
62:26	Computed EMS look angles
62:30	Computed depression angle to lunar horizon and terminator
62:40	Converted and passed vector to Goldstone and NORAD
63:20	Computed lunar groundtrack assuming nominal LOI-1 and LOI-2
64:00	Generated look angle time history tape
64:05	Computed PFAO data for MCC-4
64:45	Computed LOI-1 and LOI-2
64:56	Computed STAR OF HOPE data
65:05	Recomputed LOI crew chart data
65:15	Computed AGOP data
65:17	Computed depression angle to lunar horizon or terminator
65:19	Computed AGOP data
65:20	Computed PTC data
65:20	Computed EMS look angles

TABLE II.- APOLLO 8 RTACF ACTIVITIES - Continued

(b) Mission activities - Continued

Time, hr:min g.e.t.	Event
65:51	Computed and passed LOI-1 cutoff vector to Goldstone
66:15	Computed LOI-1 and LOI-2
66:44	Computed STAR OF HOPE data
66:46	Computed EMS look angles (five cases)
66:54	Computed EMS look angles (five cases)
66:55	Computed depression angles to lunar horizon and terminator
67:13	Computed RTE solution (abort scan)
67:18	Computed RTE solution (return to earth digitals)
67:20	Computed RTE solution (abort scan)
67:40	Computed lunar orbit groundtracks assuming nominal LOI-1 and LOI-2
67:45	Generated pointing data for all telescopes (two cases)
68:36	Computed RTE solution (abort scan)
68:40	Verified the planned LOI-1 maneuver using RTCC ΔV targets
69:10	Computed RTE solution (abort scan)
70:12	Computed RTE solution (abort scan)
70:15	Computed AGOP data (two cases)
70:18	Computed EMS look angles
70:38	Computed c.g. versus weight table and DAP load.
70:43	Computed LOI-1 PFAO data (two cases)
70:50	Computed entry aerodynamics
71:23	Computed AGOP data, including nominal LOI-2 maneuver
71:48	Converted and passed vector to NORAD and Goldstone (two cases)
72:38	Computed LOI-2 PFAO data
72:50	Computed RTE solution (abort scan)
72:55	Computed RTE solution (abort scan)
73:47	Confirmed LOI-2 with residuals
74:36	Converted and passed vector to NORAD and Goldstone
74:40	Computed lunar groundtracks
75:30	Computed RTE and G&N guided entry
75:40	Computed DAP load
75:58	Computed AGOP data
76:41	Computed LOI-2 PFAO data
76:45	Converted and passed vector to NORAD and Goldstone

TABLE II.- APOLLO 8 RTACF ACTIVITIES - Continued

(b) Mission activities - Continued

Time, hr:min g.e.t.	Event
77:00	Computed DAP load
77:11	Computed EMS look angle
77:18	Converted and passed post-TEI vector to Goldstone
77:54	Computed RTE solution (nominal TEI)
78:21	Recomputed RTE solution (nominal TEI)
78:30	Computed AGOP data (five cases)
78:40	Computed PTC attitudes (six cases)
79:10	Processed SPAN paper tape
80:02	Computed complete set of RTE data including G&N guided entry
80:29	Computed AGOP data
82:05	Computed DAP load
82:10	Computed radiation data for SPAN
82:45	Converted vector for evaluation team
82:50	Computed PTC attitudes
83:10	Computed RTE solution (abort scan)
83:15	Computed RTE solution (abort scan)
83:37	Computed RTE solution (abort scan)
84:25	Computed AGOP data (five cases)
84:26	Computed PTC attitudes
84:30	Computed landing targets based on entry range = 1800 n. mi.
85:02	Computed lunar groundtracks
85:30	Computed RTE solution
86:30	Computed AGOP data (three cases)
86:35	Computed post-LOI-2 DAP load data
86:40	Computed RTE solution (abort scan)
87:04	Recomputed post-LOI-2 DAP load data
87:30	Computed RTE solution (RTACF verify nominal TEI maneuver)
88:09	Computed EMS look angles
88:10	IBM 7094 down for approximately 1 hr
88:46	Confirmed backup TEI RTE solutions (two cases)
89:00	UNIVAC 1108 processor 1 down for approximately 1 hr
89:15	UNIVAC 418 down for approximately 15 minutes
89:47	Computed optimized RTE midcourse maneuver (MCC-5)

TABLE II.- APOLLO 8 RTACF ACTIVITIES - Continued

(b) Mission activities - Continued

Time, hr:min g.e.t.	Event
90:12	Recomputed optimized RTE MCC-5
90:15	Converted and passed vector to Goldstone and NORAD
90:25	Computed AGOP date (five cases)
90:30	Confirmed TEI maneuver with residuals
90:40	Performed maneuver evaluation of TEI
90:45	Computed RTE MCC-5 (two cases)
90:50	Computed PAO data (sphere change parameters)
91:04	Computed relative range from EI to landing longitude
91:47	Computed mass properties tables and DAP loads
91:54	Computed RTE MCC-5
92:00	Computed optimized RTE MCC
92:10	Computed four sets of telescope pointing data (two cases)
92:15	Converted star sighting data for evaluation team
92:21	Computed post-TEI DAP load data
92:30	Computed delay time and range (eight cases)
92:51	Computed EMS look angles (twelve cases)
93:01	Generated look angle time history tape
93:05	Converted star sighting data for evaluation team
93:08	Computed AGOP data (three cases)
94:36	Converted vector for evaluation team
95:24	Computed STAR OF HOPE data
95:30	Converted vector for evaluation team
96:00	Computed AGOP data
97:25	Computed delay time and range for Goldstone
97:45	Computed AGOP data (two cases)
97:50	Computed EI conditions (space digitals)
98:40	Converted and passed vector to Goldstone and NORAD
97:58	Computed pointing data for Huntsville
98:04	Computed CM NAV update
98:26	Computed altitude for specified g.e.t.
98:31	Recomputed pointing data for Huntsville
99:13	Generated look angle time history tape
99:22	Converted and passed vector to Goldstone and NORAD

TABLE II.- APOLLO 8 RTACF ACTIVITIES - Continued

(b) Mission activities - Continued

Time, hr:min g.e.t.	Event
99:52	Computed perigee conditions
100:30	Computed MCC-5
101:37	Computed EMS look angles
102:23	Recomputed MCC-5
103:20	Computed AGOP data (five cases)
103:25	Computed EMS look angles
103:32	Computed PGAO data for TEI and MCC-5 (four cases)
104:04	Confirmed MCC-5 with residual
104:30	Computed MCC-6
104:58	Computed entry groundtracks
106:00	Computed radiation data
106:20	Computed post-TEI DAP data
106:26	Computed space digital parameters
106:42	Computed EMS look angles
106:48	Computed checkout monitor parameters
107:10	Computed entry groundtracks
107:13	Converted and passed vector to Goldstone and NORAD
107:28	Computed G&N entry and passed ARIA data
107:35	Converted MSFN tape for evaluation team
107:40	Computed MCC-6
107:51	Computed AGOP data (five cases)
107:55	Converted and passed vector to Goldstone and NORAD
108:04	Computed radiation data
109:51	Computed PVT data
110:15	Computed right ascention and declination for various radar sites
110:20	Computed MCC-6
111:00	Computed AGOP data (six cases)
111:05	Computed PTC attitudes
111:07	Computed EMS look angles
111:10	Computed pointing data for various radar sites
111:30	Computed MCC-7
112:00	Confirmed MCC-5 with tracking vector
112:34	Computed MCC-6 (two cases)

TABLE II.- APOLLO 8 RTACF ACTIVITIES - Continued

(b) Mission activities - Continued

Time, hr:min g.e.t.	Event
112:52	Computed AGOP data (five cases)
112:57	Generated look angle time history tape
113:00	Converted and passed vector to Goldstone
113:16	Computed EMS look angles
113:56	Computed EMS look angles
114:30	Computed MCC-7
115:22	Computed EMS look angles
115:48	Computed MCC-6
116:07	Computed optimized MCC-6
116:10	Computed four sets of telescope point data (two cases)
116:12	Computed EMS look angles
116:15	Computed AGOP data
116:38	Converted tape for evaluation team
117:00	Computed radar pointing data for Huntsville
117:10	Computed G&N guided entry
117:30	Computed optimized MCC-7 (entry minus 2 hr)
117:35	Computed MCC-7
118:50	Converted and passed vector to Goldstone and NORAD
118:52	Computed entry groundtracks
118:55	Computed checkout monitor at specified time
119:20	Generated look angle time history tape
120:05	Computed radar pointing data for Huntsville
120:44	Computed CSM NAV update
120:51	Generated postflight ephemeris tape (two cases)
121:10	Convert star sighting data for evaluation team
122:05	Recomputed radar pointing data for Huntsville
121:41	Computed conditions at 400 000 ft with TM vector
121:56	Computed range and delay time for Guam (two cases)
122:10	Computed radar pointing data for various Huntsville locations (four cases)
122:53	Computed optimized MCC-7 (two cases)
123:15	UNIVAC 1108 processor 1 down for 15 minutes
123:47	Computed conditions at 400 000 ft with TM vector

TABLE II.- APOLLO 8 RTACF ACTIVITIES - Continued

Time, hr:min g.e.t.	(b) Mission activities - Continued Event
124:07	Computed G&N guided entry with detailed print; provided g-load time history to medical officer
124:21	Computed CSM NAV update
126:10	Converted and passed vector to NORAD
126:32	Computed predicted postseparation SM vector for Goddard
127:19	Computed G&N guided entry with detailed print
127:27	Computed EMS look angles
128:58	Computed CM/SM relative motion and SM impact point
129:02	Computed G&N guided entry with detailed print
129:54	Computed optimized MCC-7
130:40	Recomputed CM/SM relative motion
131:16	Computed entry aerodynamics
131:18	Recomputed entry aerodynamics
131:40	Computed checkout monitor at 400 000 ft
132:04	Computed EMS look angles
132:05	Updated RTACF entry aerodynamics (and passed required c.g.'s to RETRO to update RTCC)
132:15	Computed checkout monitor at 400 000 ft
132:30	Computed AGOP data
132:35	Computed entry groundtracks
132:40	Computed checkout monitor at 400 000 ft
133:11	Computed checkout monitor at 400 000 ft with MCC-7 assumed (two cases)
133:33	Computed PVT data
134:18	Computed entry pointing data for Johnson Island
134:25	Computed entry groundtracks
134:29	Computed SM pointing data
135:00	Generated postflight ephemeris tape (two cases)
135:14	Computed AGOP data (two cases)
137:48	Computed SM impact point
137:55	Computed G&N guided entry
138:15	Converted and passed vector to NORAD
138:22	Computed entry groundtracks
138:40	Computed G&N guided entry
139:00	Computed entry aerodynamics

TABLE II.- APOLLO 8 RTACF ACTIVITIES - Concluded

(b) Mission activities - Concluded

Time, hr:min g.e.t.	Event
139:22	Computed range from 400 000 ft to landing target
139:25	Computed G&N guided entry
140:24	Computed CM/SM relative motion
140:25	Computed G&N guided entry (new aerodynamics)
140:30	Updated RTACF entry aerodynamics (and passed required c.g.'s to RETRO to update RTCC)
141:52	Computed entry PFAO data (two cases)
142:00	Computed G&N guided entry
142:02	Computed entry groundtrack
142:05	Computed radar pointing data for Huntsville and Goldstone
142:47	Computed range and delay time for HSK
142:56	Computed G&N guided entry
143:05	Computed and passed entry time sequence to recovery
143:25	Computed entry aerodynamics
143:30	Computed CSM NAV update
143:46	Updated RTACF aerodynamics and passed required c.g.'s to RETRO
144:08	Computed entry aerodynamics (new water configuration)
144:10	Computed G&N guided entry
144:12	Computed EMS look angles
144:19	Computed SM entry using 90-sec burn instead of burn to depletion
144:28	Computed G&N guided entry
145:03	Computed radiation data
145:50	Computed G&N guided entry
146:05	Computed CM/SM relative motion
146:12	Computed G&N guided entry
146:31	Computed PFAO CM/SM separation data
146:50	Computed PFAO 400 000-ft data
147:00	APOLLO 8 splashed on target

TABLE III.- SUMMARY OF RTACF COMPUTATIONS

	Type	Number of computations
1.	Translunar midcourse	26
2.	Transearth midcourse	12
3.	LOI-1	14
4.	LOI-2	9
5.	Return to earth (RTE)	99
6.	Apollo generalized optics program (AGOP)	101
7.	Spacecraft system and consumable computations	14
8.	Earth-moon-sun (EMS) look angles	40
9.	Telescope look angles	26
10.	Conversion of vectors for the Jet Propulsion Laboratory (JPL)	38
11.	Crew chart update	10
12.	Maneuver confirmation	2
13.	Maneuver evaluation	9
14.	Radiation	2
15.	Solar Particle Alert Network (SPAN) date reduction	5
16.	LOI GO/NO-GO computation	3
17.	Onboard navigation and Manned Space Flight Network (MSFN)	307
18.	Mass properties computations	44
19.	Groundtracks	17
20.	Command and service module (CSM) or S-IVB Navigation update	10
21.	Delay time (slant range)	39
22.	Entry data for track controller	10
23.	Post Flight Analysis Office (PFAO) computations	21
24.	Radar tracking	2
25.	Look-angle time history tape	6
26.	Generation of ephemeris tape	14
27.	General computation	228
	TOTAL COMPUTATIONS =	1108

TABLE IV.- RTACF MANPOWER UTILIZATION

Prelaunch Phase

Name	Position
L. D. Davis	Trajectory Support Chief
S. D. Holzaepfel	Assistant Trajectory Support Chief
M. A. Collins, Jr.	Data Management
S. R. Newman	Mode I Abort Specialist
D. G. Ives	Mode I Abort Specialist

Launch Through MCC1

L. D. Davis	Trajectory Support Chief
E. R. Hischke	Assistant Trajectory Support Chief
J. C. Harpold	Entry Specialist
J. R. Elk	Maneuver Specialist
C. H. Drinnan	Maneuver Specialist
R. J. Gerbracht	RTC Specialist
C. R. Huss	MPAD Representative
M. A. Collins, Jr.	Data Management
R. O. Nobles	Guidance Specialist
H. S. Estes	Guidance Specialist
R. S. Davis	RTCC Program Specialist
W. R. Lee	RTCC Program Specialist
E. M. Henderson	Launch Abort Specialist
B. F. McCreary	Postflight Observer
C. J. Trigg	Engineering Aide

TABLE IV.- RTACF MANPOWER UTILIZATION - Continued

MCC1 to MCC4
(Translunar Coast)

Name	Shift	Position
L. D. Davis	1	Trajectory Support Chief
H. Garcia	2	Trajectory Support Chief
S. D. Holzaepfel	3	Trajectory Support Chief
E. R. Hischke	1	Assistant Trajectory Support Chief
C. E. Allday	2	Assistant Trajectory Support Chief
T. L. Turner	3	Assistant Trajectory Support Chief
M. A. Collins, Jr.	1	Data Management
R. E. Simms	3	Data Management
R. O. Nobles	LOI GO/NO-GO only	Guidance Specialist
H. S. Estes	LOI GO/NO-GO only	Guidance Specialist
J. C. Harpold	GO/NO-GO only	Entry Specialist
J. R. Elk	1	Maneuver Specialist
Q. S. Holmes	2	Maneuver Specialist
C. H. Drinnan	3	Maneuver Specialist
R. J. Gerbracht	1	Abort Specialist
H. P. Reinhardt	2	Abort Specialist
C. J. Laetz	3	Abort Specialist
R. S. Davis	1	RTCC Program Specialist
W. R. Lee	2	RTCC Program Specialist
D. R. Davis	3	RTCC Program Specialist
B. F. McCreary	1	Postflight Observer
W. R. Lacy	2	Postflight Observer
F. J. Smith	3	Postflight Observer
R. P. Parten	1	MPAD Representative
W. J. Bennett	2	MPAD Representative
J. A. McAnulty	3	MPAD Representative
C. J. Trigg	1	Engineering Aide
B. L. Hester	2	Engineering Aide
M. E. Crawford	3	Engineering Aide

TABLE IV.- RTACF MANPOWER UTILIZATION - Continued

MCC4 to MCC5
(Lunar Sphere)

Name	Shift	Position
L. D. Davis	1	Trajectory Support Chief
H. Garcia	2	Trajectory Support Chief
S. D. Holzaepfel	3	Trajectory Support Chief
E. R. Hischke	1	Assistant Trajectory Support Chief
C. E. Allday	2	Assistant Trajectory Support Chief
T. L. Turner	3	Assistant Trajectory Support Chief
M. A. Collins, Jr.	1	Data Management
R. D. Simms	3	Data Management
J. C. Harpold	1	Entry Specialist
J. K. Burton	2	Entry Specialist
R. H. Manders	3	Entry Specialist
R. F. Wiley	MCC4 to LOI	Maneuver Specialist
S. R. Newman	1	Abort Specialist
C. E. Foggatt	2	Abort Specialist
C. T. Hyle	3	Abort Specialist
F. M. Northcutt	2	RTCC Program Specialist
R. S. Davis	1	RTCC Program Specialist
D. S. Gafford	3	RTCC Program Specialist
B. F. McCreary	1	Postflight Observer
W. R. Lacy	2	Postflight Observer
F. J. Smith	3	Postflight Observer
R. P. Parten	1	MPAD Representative
W. J. Bennett	2	MPAD Representative
J. A. McAnulty	3	MPAD Representative
C. J. Trigg	1	Engineering Aide
B. L. Hester	2	Engineering Aide
M. E. Crawford	3	Engineering Aide

TABLE IV.- RTACF MANPOWER UTILIZATION - Continued

MCC5 to MCC8
(Transearth Coast)

Name	Shift	Position
L. D. Davis	1	Trajectory Support Chief
H. Garcia	2	Trajectory Support Chief
S. D. Holzaepfel	3	Trajectory Support Chief
E. R. Hischke	1	Assistant Trajectory Support Chief
C. E. Allday	2	Assistant Trajectory Support Chief
T. L. Turner	3	Assistant Trajectory Support Chief
J. C. Harpold	1	Entry Specialist
J. K. Burton	2	Entry Specialist
R. H. Manders	3	Entry Specialist
R. J. Gerbracht	1	Abort Specialist
H. P. Reinhardt	2	Abort Specialist
C. J. Laetz	3	Abort Specialist
M. A. Collins, Jr.	1	Data Management
R. E. Simms	3	Data Management
B. F. McCreary	1	Postflight Observer
W. R. Lacy	2	Postflight Observer
F. J. Smith	3	Postflight Observer
R. P. Parten	1	MPAD Representative
W. J. Bennett	2	MPAD Representative
J. A. McAnulty	3	MPAD Representative
C. J. Trigg	1	Engineering Aide
B. L. Hester	2	Engineering Aide
M. E. Crawford	3	Engineering Aide

TABLE IV.- RTACF MANPOWER UTILIZATION - Concluded

Entry

Name	Position
L. D. Davis	Trajectory Support Chief
E. R. Hischke	Assistant Trajectory Support Chief
M. A. Collins, Jr.	Data Management
J. C. Harpold	Entry Specialist
J. K. Burton	Entry Specialist
B. F. McCreary	Postflight Observer
R. P. Parten	MPAD Representative
C. J. Trigg	Engineering Aide
B. L. Hester	Engineering Aide
M. E. Crawford	Engineering Aide

Auxiliary Computing Room

Name	Shift	Position
C. D. Chenoweth	1	ACR Chief
R. D. Davis	2	ACR Chief
D. C. McDougall	3	ACR Chief
R. W. Witton	1	Trajectory Specialist
H. L. Sanders	1	Trajectory Specialist
V. R. Dragotta	1	Trajectory Specialist
W. R. Pruett	2	Trajectory Specialist
L. Baker	2	Trajectory Specialist
D. W. Sager	2	Trajectory Specialist
J. H. Kawasaki	3	Trajectory Specialist
P. A. DiValerio	3	Trajectory Specialist
B. G. Schneider	3	Trajectory Specialist
J. W. Tolin	1	Entry Specialist
K. T. Zeiler	1	Maneuver Specialist
E. J. Svrcek	1	Maneuver Specialist
G. Weiskopf[a]	1	Maneuver Specialist
A. E. Morrey	2	Maneuver Specialist
J. A. Herbal	2	Maneuver Specialist
B. O. McCaffety	3	Maneuver Specialist
T. J. Linbeck	3	Maneuver Specialist
D. R. Wiggins	1	Run Coordinator
B. N. Ferguson	2	Run Coordinator
J. E. Frieble	3	Run Coordinator
L. A. Holden	1	Engineering Aide
J. W. King	2	Engineering Aide
G. K. Carroll	3	Engineering Aide

[a]On call.

TABLE V.- TYPICAL RTACF SUPPORT TEAM

[Simulation or mission]

Position	Number of Personnel
SSR Staff	
Trajectory Support Chief	1
Assistant Trajectory Support Chief	1
Maneuver Specialist (midcourse/LOI/entry)	2
Abort Specialist	1
RTCC Abort Support	1
Nontechnical Support Personnel	1
ACR Staff	
ACR Chief	1
Trajectory Analyst	3
Maneuver Consultant	2
Program Consultant	2
Onboard Navigation - MSFN Evaluation Team	4
Nontechnical Personnel	8
TOTAL	27

TABLE VI.- APOLLO 8 RTACF FLIGHT CONTROL SIMULATION (SIM) SUPPORT SUMMARY

Date of sim	Type	No. of SSR personnel	No. of ACR personnel required for sim support	Additional no. of ACR personnel present for checkout and training[a]	Manhours (SSR + ACR) required for sim support	Total manhours used during sim (SSR + ACR)	Length of sim, hr
10/26/68	TLI	8	10	20	198	418	11
10/30/68	TLI	8	10	20	198	418	11
10/31/68	LOI/TEI	7	9	21	160	370	10
11/01/68	TLC	6	9	21	150	360	10
11/04/68	TLI	6	10	20	160	360	10
11/05/68	LOI/TEI	7	9	21	160	370	10
11/06/69	LOI/TEI	5	9	21	140	350	10
11/07/68	Entry	6	8	22	126	324	9
11/13/68	Entry	6	8	22	126	324	9
11/14/68	LOI/TEI	7	9	21	160	370	10
11/20/68	LOI/TEI	6	9	21	150	360	10
11/21/68	TLC	6	9	21	150	360	10
11/22/68	TLI	6	10	20	176	396	11
11/23/68	LOI/TEI	5	9	21	154	385	11
11/25/68	LOI/TEI	5	9	21	154	385	11
11/26/68	LOI/TEI	5	9	21	140	350	10
11/27/68	Earth orbit	5	7	18	108	270	9
12/03/68	TLI	6	10	15	160	310	10
12/04/68	TLC	6	9	16	135	279	9
12/11/68	CDDT	4	4	8	64	128	8
12/12/68	LOI/TEI	7	9	16	176	352	11
12/13/68	Entry	6	8	17	140	310	10
12/14/68	Network	7	11	14	198	352	11
12/16/68	TLI	7	11	14	198	352	11
12/17/68	Network	7	11	14	198	352	11

[a]Includes personnel doing checkout and verification, support personnel, and evaluation team.

TABLE VII.- REQUIRED RTACF SUPPORT

(a) Manpower required for in-house simulations

Number of in-house simulations	11
Total in-house simulation hours	62
Average technical personnel present	12
Average nontechnical personnel present	8
Evaluation team personnel present	2
Total manpower required	1364

(b) Flight control simulation summary

	ACR	SSR
Number of flight control simulations	25	25
Average length of simulations, hr	10	10
Average technical personnel per simulation	9.5	6
Average nontechnical personnel per simulation	8	1
Additional technical personnel present for verification and training	(18)	(2)
Evaluation team present	4	--
Total personnel required for simulation support	(21.5)	7
Total technical personnel present during simulations	(31.5)	8
Total technical technical manpower required for simulation support	3375	1500
(Total technical manpower present during simulation)	(7875)	(2000)
Total nontechnical manpower required for simulation support	2000	250
Total manpower required for simulation support	5375	1750
TOTAL (ACR and SSR)	7125	

TABLE VII.- REQUIRED RTACF SUPPORT - Concluded

(c) Manpower required for mission support

Position	Number of personnel	Length of time present, hr	Total manhours
SSR staff			
Trajectory support chief	1	153	153
Assistant trajectory support chief	1	153	153
Maneuver specialist	2	149	198
Abort specialist	1	149	149
RTCC abort support	1	149	149
Nontechnical support personnel	1	153	153
ACR staff			
ACR chief	1	153	153
Trajectory analyst	3	153	459
Maneuver consultant	2	149	198
Program consultant	2	153	206
Onboard navigation MSFN evaluation team	4	147	588
Nontechnical personnel	8	153	1224
TOTAL			3783

(d) Total manpower required for Apollo 8 support (ACR and SSR)

Total in-house simulation support (ACR only)	1364
Total flight control simulation support (ACR)	5375
Total flight control simulation support (SSR)	1750
Total mission support (ACR)	2828
Total mission support (SSR)	955
Total Apollo 8 manpower (manhours)	12 272